ARTICLE SURVEILLANCE SYSTEM

Field of the Invention

The present invention relates to a method of detecting in an electronic article surveillance system whether an alarm condition exists according to the preamble to claim 1, and an electronic article surveillance system according to the preamble to claim 6.

Background Art

Electronic article surveillance systems, below referred to as EAS systems (EAS = Electronic Article Surveillance), are used in shops to detect attempted shoplifting. If a visitor without permission leaves a shop carrying an article, the system sounds the alarm.

Such systems are based on an antenna unit emitting an electromagnetic field. If an alarm label containing a resonance circuit comes within the surveillance area of the antenna unit (for instance at the exit of a shop), this circuit is brought into resonance by the field. When the antenna unit is switched off, the alarm label itself emits a weak signal which is captured by an antenna unit. In that case, an alarm, for instance a sounding alarm, can be initiated.

In prior-art systems, the received signal is mixed down to a low frequency or to a direct voltage. A problem with this approach is that it is susceptible to interference. Since the signal normally received from an alarm label is very weak, a source of interference at a great distance is sufficient to initiate a false alarm.

Summary of the Invention

An object of the present invention is to wholly or at least partly eliminate the above problem. This object

is achieved by a method according to claim 1 and an electronic article surveillance system according to claim 5.

According to a first aspect, there is provided a method of detecting in an electronic article surveillance system whether an alarm condition exists. The article surveillance system emits, in transmission pulses, an electromagnetic field and receives, between the transmission pulses, reply signals from at least one alarm label which is located within the surveillance zone of the article surveillance system. The method comprises the steps of, after completed transmission of a transmission pulse, sampling a received reply signal, identifying zero crossings of the sampled reply signal, determining agreement between phase positions of the zero crossings and corresponding phase positions of zero crossings of a reply signal, received and sampled after a previously emitted transmission pulse, and making an alarm decision on the basis of the degree of agreement in phase position.

Such a method eliminates essentially the entire effect of sources of interference that are not in constant phase with the transmission pulse of the system and therefore enables much safer alarm detection than systems where an analysis is made on a mixed-down signal.

In a preferred embodiment, said previously emitted transmission pulse is the preceding transmission pulse.

Preferably, an alarm is initiated if the degree of agreement in phase position of the zero crossings exceeds a predetermined value.

In a preferred embodiment, the alarm decision can be made on the basis of an additional characteristic of the received reply signal, for instance the envelope of the received reply signal.

According to a second aspect, the invention relates to an electronic article surveillance system, comprising means for detecting whether an alarm condition exists, which article surveillance system in transmission pulses

emits an electromagnetic field and between the transmission pulses receives reply signals from at least one alarm label which is located within the surveillance zone of the article surveillance system. The system is charac-
5   terised by means for sampling a response signal, received after completed transmission of a transmission pulse, means for identifying zero crossings of the sampled reply signal, means for determining agreement between phase positions of the zero crossings and corresponding phase
10   positions of zero crossings of a reply signal, received and sampled after a previously emitted transmission pulse, and means for making an alarm decision on the basis of the degree of agreement in phase position.

The system gives the same advantages as does the
15   above-mentioned method and may be varied similarly.

Brief Description of the Drawings

Fig. 1 illustrates schematically components of an EAS system.
20   Fig. 2a illustrates schematically an EAS system in a transmission mode.

Fig. 2b illustrates schematically an EAS system in a reception mode.

Fig. 3 is a flow chart of a method according to an
25   embodiment of the invention.

Fig. 4 illustrates functional modules of a control unit of an electronic surveillance system according to an embodiment of the invention.

30   Description of Preferred Embodiments

Fig. 1 illustrates schematically components of an EAS system. The system comprises at least one antenna unit 1, which in most cases is placed in the vicinity of the exit of a shop. The antenna unit 1 can be arrang-
35   ed on a stand 3 and contains a resonance circuit which is used to emit an electromagnetic field, for instance at the frequency 58 kHz. The antenna unit 1 is also used

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to receive a reply signal from an alarm label, as will be
described below. The antenna unit 1 monitors a surveil-
lance zone.

The antenna unit 1 is connected to a control unit 5
by a cable 7. The control unit 5 supplies power to the
antenna unit 1 when transmitting and receives signals
from the same during reception. A control unit 5 can be
used together with a plurality of antenna units 1 and
can therefore be used to monitor a plurality of exits or
other locations in a shop. If the control unit 5 detects
a condition when an alarm is justified, i.e. when a pro-
tected article is located within the surveillance zone
of the antenna unit, an alarm is initiated, for instance
so that an alarm buzzer (not shown) starts to sound. The
alarm buzzer can be integrated, for instance, in the
antenna unit 1.

Fig. 2a illustrates schematically, seen from above,
an EAS system in a transmission mode. In transmission,
the antenna unit 1 emits an electromagnetic field which
transmits energy to an alarm label 9 which can also be
referred to as a transponder. The alarm label 9 contains
a resonant element, which is tuned with the frequency of
the electromagnetic field emitted by the antenna unit 1.

Fig. 2b illustrates schematically, seen from above,
an EAS system in a reception mode during a monitoring
interval. In the reception mode, the previously shown
control unit 5 has switched off the transmission of the
antenna unit 1. Instead, a reply signal in the form of
electromagnetic energy is received from the alarm label
9, i.e. the energy previously emitted by the antenna unit
1. Thus the alarm label 9 can be completely passive and
does not require any power supply of its own.

Various configurations of antenna units 1 are con-
ceivable. In some cases, use is made of an antenna unit,
at an exit or some other location in a shop, both for
transmission and reception. This means that one antenna
unit is sufficient to monitor a surveillance zone. In

other cases, use is made of two antenna units, which are
used both for transmission and reception, which results
in a larger surveillance zone. In still other cases, two
antenna units are used, one for transmission and the
other for reception, which is particularly convenient
when protected articles are stored close to the antenna
units.

Fig. 3 is a flow chart of a method according to an
embodiment of the invention. According to the method,
an alarm decision is made, the risk of false alarm being
very small.

In a first step 11, the received signal is sampled.
In a preferred embodiment, only filtering and amplifica-
tion of the received signal occur before sampling takes
place. Thus, mixing down of the incoming signal usually
does not occur. Filtering and amplification occur for the
purpose of, for instance, eliminating interference from
electric mains, lighting etc. If the EAS system itself
transmits at 58 kHz, a bandpass filter thus is used,
which is tuned to 58 kHz. If the expected signal fre-
quency is 58 kHz, sampling may preferably occur at the
frequency 400 kHz. The sampling is started a predetermin-
ed period of time after completion of the transmission
pulse of the system and with a predetermined relationship
to the signal phase of the transmission pulse, i.e. to
the phase of the 58 kHz signal.

In a second step 13, the sampled signal is A/D con-
verted. The A/D converted signal is stored in a buffer,
preferably with double precision, i.e. 32 bits.

In a third step 15, the signal stored in step 13 is
alpha filtered with the signal which in the same way has
been stored and filtered after the preceding transmission
pulse, i.e. in the preceding monitoring interval. By
alpha filtering the following is meant

$$X(n) = \frac{X_m}{\alpha} + (\alpha - 1) \cdot \frac{X(n-1)}{\alpha}$$

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wherein X_m is the amplitude in a buffer position in the
signal stored in step 13, X(n-1) is the result of the
filtering of the corresponding buffer position in the
preceding monitoring interval and X(n) the result of the
filtering of the corresponding buffer position in this
monitoring interval. α is a parameter, which is deter-
mined empirically, for instance α = 16. Filtering is
performed for all buffer positions. Thus alpha filtering
is a kind of averaging, where signals not synchronised
with the system, i.e. with the phase of the transmission
pulse, are eliminated essentially completely.

In a fourth step 17, the result of the signal pro-
cessing in step 15 is stored in a buffer, now with single
precision, i.e. 16 bits.

In a fifth step 19, the zero crossings of the signal
stored in step 17 are identified and compared with the
zero crossings of a signal previously stored in the same
manner and collected in a preceding monitoring interval.

It is checked in a sixth step 21 whether the phases
of the zero crossings of these signals agree to a suffi-
cient extent. By agreement is meant that zero crossings
appear in corresponding positions in the buffer. For
example, the criterion can be that 95% of the zero cross-
ings must agree. If this is the case, it is quite prob-
able that an alarm condition exists, i.e. that an alarm
label is located within the surveillance area of the EAS
system. The system then proceeds to a seventh step 23.
Otherwise it returns to the first step 11 and awaits
sampling in the next monitoring interval. The fact that
the agreement of the phase positions is an excellent
alarm criterion is due to the fact that alarm labels
always have the same phase relationship with the pulsed
field. Extraneous sources of interference within the same
frequency band will "creep" in relation to the 58 kHz
signal of the system.

In the optional seventh step 23, it is checked
whether other criteria, if any, of an alarm condition

are satisfied. For instance it may be convenient to
check the envelope of the received signal, as is pre-
viously known per se. The envelope is clearly dependent
on the Q value of the resonance circuit of the alarm

5   label. If some other article has been brought into reso-
nance by the transmission pulse of the system, the enve-
lope will therefore have a different appearance.

       If the other criterion is satisfied, the system
initiates an alarm in an eighth step 25. Otherwise, it

10   returns to the first step 11 where sampling occurs again
after the next transmission pulse.

       Fig. 4 shows functional modules of a control unit
5 of an electronic surveillance system according to an
embodiment of the invention. It comprises a bandpass fil-

15   ter and an amplifier (not shown), a Sample/Hold circuit
27, an A/D converter 29 and a buffer 31 where output
data from the A/D converter 29 are stored.

       A control unit 33 reads data from the buffer 31,
signal processes them, as described above, and stores

20   the result in the buffer 31. Moreover the control unit 33
makes a check of the agreement between phase positions of
the zero crossings of the signals, as previously mention-
ed, and also a check of other criteria. If the alarm cri-
teria are satisfied, the control unit 33 initiates an

25   alarm of an alarm unit 35.

       It will be appreciated that the above functional
modules can be accomplished in various ways, with soft-
ware and hardware. For instance, it is preferred to
accomplish the A/D converter 29, the buffer 31 and the

30   control unit 33 with a digital signal processor (DSP).

       In brief, the invention concerns an electronic
article surveillance system, which in pulses emits an
electromagnetic field, and in monitoring intervals
between the pulses receives reply signals from alarm

35   labels within the surveillance area of the system.
An incoming signal is sampled in the system. The zero
crossings of the sampled signal are identified, and

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their phase positions are compared with corresponding
phase positions of zero crossings of an incoming signal,
received and sampled in a previous monitoring interval.
If these phase positions agree sufficiently well, an
5   alarm can be initiated.

The invention is not restricted to the embodiments
illustrated above and may be varied within the scope of
the appended claims.